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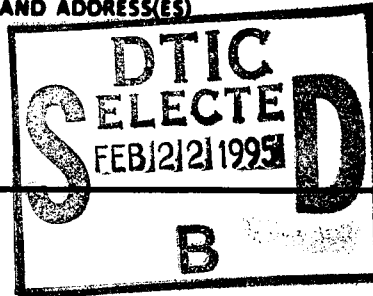
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Foreign Travel Trip Report for the 20th International Towing Tank Committee Cavitation Committee Meeting and International Symposium on Propulsors and Cavitation.

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**Final Report**

Foreign Travel Trip Report

by

Michael L. Billet

10 August 1992

Enclosure (1): Trip Report

**Date:** 15 June 1992  
**Location:** Lausanne, Switzerland

I visited Dr. Francois Avellan at the Institut de Machines Hydrauliques et de Mecanique des Fluides, Ecole Polytechnique Federale De Lausanne to discuss developed cavitation research. The institute is well known for hydraulic turbine/pump testing and research. Currently, Dr. Avellan is heading the cavitation research efforts and has four Ph.D. candidates working on a model of cavitation erosion from developed cavitation. In addition, research on the effect of nuclei seeding has continued. The ongoing research on developed cavitation is particularly note worthy on identifying the unsteady structure and should be followed closely. A seminar entitled "Cavitation in Pumps," was presented at the institute.

**Date:** 22-25 June 1992  
**Location:** Hamburg, Germany

The International Symposium on Propulsor and Cavitation sponsored by the Hamburgische Schiffbau-Versuchsanstalt was held on 22 June to 25 June 1992 in Hamburg, Germany. The Symposium had approximately 150 participants and the international cavitation community was very well represented. Most of the papers appeared to be progress reports or assessments of current technology problems. One interesting note is the move to Navier-Stokes analysis of propeller flow and away from potential methods which resulted in many discussions on this point. I served as Chairman of Session 2 and presented a paper entitled "Propeller Tip Cavitation Suppression Using Selective Polymer Injection," authored by George Chahine.

**Date:** 21 and 22 June 1992  
**Location:** Hamburg, Germany

Two meetings of the 20th International Towing Tank Conference (ITTC) Cavitation Committee were held to discuss progress of report preparation. A copy of the minutes is enclosed.

**Date:** 29 June - 10 July 1992  
**Location:** The Large Hydrodynamic Tunnel (GTH), Val de Reuil, France

A two week test was conducted jointly by the 20th ITTC Cavitation Committee and the Bassin d'Essais des Carènes at the Grande Tunnel Hydrodynamic (GTH). The purpose of these tests was to quantify the importance of microbubbles on the inception of three propeller cavitation types: leading edge sheet, bubble and tip vortex cavitation. The GTH, which has a complete control system including dissolved gas and microbubble control, offered the opportunity to answer this question. In addition, the GTH on-line Cavitation Susceptibility Meter allowed the microbubble number and the dimension (tension) of the test water to be determined.

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During the first week, the Cavitation Susceptibility Meter (centerbody venturi) measurements were compared to results with Phase Doppler Particle Analyzer (PDPA) and Holography. In addition, the tunnel nuclei seeding system was calibrated in order to determine a range of bubble number size and liquid tension.

Cavitation inception data, photographs, and noise were obtained for four different values of microbubble distributions on each of the three propellers. The propellers were 34 cm in diameter and were designed by MARIN to have different types of cavitation. Initial analyses of the data indicate significant difference in cavitation inception were found for varying microbubble distributions and that each type showed a different dependency. Some of these results are currently being written for the 20th ITTC Cavitation Committee report. The results will also appear as a French report and as a ASME paper. In my opinion, a landmark test was conducted using a new facility.

The operation of the facility went very smoothly and I was very impressed at the microbubble control system. The Bassin d'Essais des Carènes was an excellent host and special recognition to Dr. Bernard Gindroz who organized the tests.

**Date:** 30 June 1992

**Location:** Ecole Nationale Supérieure de Techniques Avancées, Palaiseau, France

A seminar entitled "Cavitation in Pumps," was given at ENSTA and I visited the laboratory of Dr. Daniel Fruman. Dr. Daniel Fruman has been conducting experiments on the structure and scaling of the tip vortex. Currently, he is coordinating a four-year program with ENSTA, the Naval School at Brest, the Bassin d'Essais des Carènes, and the University of Grenoble in this area. The most precise LDV measure of the tip vortex roll-up are currently being done under this program. It is important to keep in touch with this effort. In addition, the French are currently using a thermodynamic model of cavitation developed by William Holl and me to predict the performance of the rocket pumps.

**Date:** 3 July 1992

**Location:** Laboratoire National d'Hydraulique, Electricité de France, Chatou, France

I was invited to visit the Pump/Turbine Testing Laboratories of the Electricité de France. An extensive research effort is being conducted to measure the flow field inside of axial and centrifugal pumps. These results are being compared to a three-dimensional Reynolds Averaged Navier-Stokes Code (N3S). The code utilizes a staggered grid and it is being developed via national project. I was very impressed at the comparisons for separated flow in centrifugal pumps.

The following reports have been issued based on the travel monies received:

- (1) Cavitation Committee Report, 20<sup>th</sup> ITTC, San Francisco, CA, September 19-25, 1993
- (2) Bernard Gindroz and Michael L. Billet, "Influence of the Nuclei on the Cavitation Inception for Different Types of Cavitation on Ship Propellers," Cavitation Inception Symposium, ASME, New Orleans, LA, November 28-December 3, 1993.
- (3) Bernard Gindroz and Michael L. Billet, "Nuclei and Acoustic Cavitation Inception on Ship Propellers," Second International Symposium on Cavitation, Tokyo, Japan, April 5-7, 1994.

Schiffbautechnische Gesellschaft e.V. -

and

Hamburgische Schiffbau-  
Versuchsanstalt G.m.b.H.

International Symposium  
on  
Propulsors and Cavitation

## **Final Program**

June 22nd. to 25th., 1992.

Hamburg

Germany

# International Symposium on Propulsors and Cavitation

## Final Program

Monday, June 22nd, 1992

8.45 - 9.15 h      Registration at TK, Bramfelderstr. 140  
9.15 - 9.25 h      Welcome Address

### Session 1: Propulsion and Cavitation I

Chairmen : E. J. Glover, University Newcastle, UK  
H. Söding, Universität Hamburg, Germany

9.40 - 10.20 h      Aspects of High Speed Propulsion, Invited Paper,  
Paper No 1.1      C. Kruppa, Technische Universität Berlin, Germany

10.20 - 11.00 h      On the Design of Optimum Ship Screw Propellers, including  
Paper No 1.2      Propellers with End Plates  
K. de Jong, University of Groningen, The Netherlands

11.00 - 11.30 h      Coffee Break

11.30 - 12.10 h      Design and Evaluation of New Propeller Blade Sections  
Paper No 1.3      M. J. Stanier, ARE Haslar, United Kingdom

12.10 - 12.50 h      Prediction of Propeller Performance and Cavitation based on the Numerical  
Paper No 1.4      Modeling of Propeller Vortex System  
N. Ishii, Akishima Laboratories (MITSUI ZOSEN) INC., Japan

12.50 - 13.45 h      Lunch

### Session 2: Propulsion and Cavitation II

Chairmen : M. L. Billet, ARL, Pennstate University, State College, USA  
M. Schmiechen, VWS Berlin, Germany

13.45 - 14.25 h      On Propeller-Rudder-Interaction  
Paper No 2.1      A. M. Kracht, VWS Berlin, Germany

14.25 - 15.05 h      Experimental Analysis of the Powering Characteristics of a Pumpjet  
Paper No 2.2      Propelled Ship  
T. van Terwisga (MARIN) and S. Kaul (SYSTEC)  
Maritime Res. Inst. Netherland, Wageningen, The Netherlands  
Gesellschaft f. Systemtechnologie, Spay, Germany

15.05 - 15.30 h      Coffee Break

15.30 - 16.10 h      Propeller Vane Wheel Interaction, Demonstrated by Time Dependent Flow  
Paper No 2.3      Velocity Measurements in a Propeller's Slipstream with  
and without Vane Wheel  
J. Blaurock and G. Lammers, HSVA, Hamburg, Germany

16.10 - 16.50 h      Postswirl Propulsors - A Design Method and an Application  
Paper No 2.4      B. Y.-H. Chen, David Taylor Research Center, Bethesda, USA

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16.50 - 17.30 h      Survey on Recent Achievements in Hydroacoustics, Invited Paper  
Paper No 5.1      W. K. Blake, David Taylor Research Center, Bethesda, USA

Tuesday, June 23rd, 1992

**Session 3: Cavitation Phenomena I**

**Chairmen :** A. J. Acosta, Caltec, Pasadena, USA  
A. Basić, Brodarski Institute, Zagreb, Croatia

- 9.00 - 9.40 h      **Cavitation in Hydraulic Turbomachines - State-of-the-Art and**  
Paper No 3.1      **Topics of Actual Research, Invited Paper**  
B. Stoffel, Technische Hochschule Darmstadt, Germany
- 9.40 - 10.20 h    **Some Effects of Surface Roughness on Cavitation Inception**  
Paper No 3.2    W. Faller, (SEWR), M. Farhat and F. Avellan, (EPFL)  
Sulzer Escher Wyss, Ravensburg, Germany  
Inst. Hydr. Machines a. Fluid Mechanics, Lausanne, Switzerland
- 10.20 - 11.00 h   **Cavitation Effects on Hydrodynamic Forces**  
Paper No 3.3    Y. T. Shen, S. Gowing, and W.G. Souders,  
David Taylor Research Center, Bethesda, USA
- 11.00 - 11.30 h    Coffee Break
- 11.30 - 12.10 h   **Velocity, Size, and Viscosity Scaling Laws, for Cavitation Inception**  
Paper No 3.4    **Developed under Consideration of the Tensile Strength of the Test Liquid**  
A. P. Keller, and G. Eickmann, Versuchsanstalt für Wasserbau,  
T. U. München, Germany
- 12.10 - 12.50 h   **Recent Investigations of the Free Air Content and its Influence on**  
Paper No 3.5    **Cavitation and Propeller-Excited Pressure Fluctuations**  
H. Tanger, H. Streckwall, E.-A. Weitendorf, (HSVA), and L. Mills, (IfS)  
Hamburg, Germany
- 12.50 - 13.45 h    Lunch

**Session 4: Cavitation Phenomena II**

**Chairmen :** G. Kuiper, (MARIN), Wageningen, The Netherlands  
W.-H. Isay, Universität Hamburg, Germany

- 13.45 - 14.25 h   **Recent Advances in Tip Vortex Cavitation Research**  
Paper No 4.1    R. E. A. Arndt and Christian Dugue, St. Anthony Falls Hydr. Laboratory  
University of Minnesota, Minneapolis, USA
- 14.25 - 15.05 h   **Propeller Tip Cavitation Suppression using Selective Polymer Injection**  
Paper No 4.2    G. L. Chahine, G. Frederick, and B. Bateman  
DYNAFLOW Inc., Fulton, Maryland, USA  
Speaker: M. L. Billet, ARL, Pennstate University, State College, USA
- 15.05 - 15.30 h    Coffee Break
- 15.30 - 16.10 h   **Observation of Cavitation and Wake Structure of Unsteady Tip Vortex Flows**  
Paper No 4.3    D. P. Hart, A. Acosta, and A. Leonard  
California Institute of Technology, Pasadena, USA
- 16.10 - 16.50 h   **Numerical Analysis of a Cavitating Hydrofoil with Finite Span**  
Paper No 4.4    H. Kato, N. Takasugi, and H. Yamaguchi, University of Tokyo, Japan
- 16.50 - 17.30 h   **Harmonic Cascading in Bubble Clouds**  
Paper No 4.5    S. Kumar, (ENSTA) and C. E. Brennen (CIT), Ecole Nat. Supérieure de  
Techniques Avancées, Palaiseau, France, Cal. Inst. of Techn., Pasadena, USA



Wednesday, June 24nd, 1992

**Session 5: Cavitation and Noise**

**Chairmen:** N. C. Sponagle, Def. Res. Est. Atlantic, Dartmouth, Nov. Scotia, Canada  
K. Albrecht, München, Germany

9.00 - 9.40 h Correlation Investigations in the New Hydrodynamics- and Cavitation Tunnel  
Paper No 2.5 (HYKAT) of the Hamburg Ship Model Basin (HSVA)  
J. Friesch and C. Johannsen, HSVA, Hamburg, Germany

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9.40 - 10.20 h Advanced Views of Cavitation Noise  
Paper No 5.2 H.-J. Baiter, Fraunhofer-Forschungsgruppe f. Hydroakustik (FHAK),  
Ottobrunn, Germany

10.20 - 11.00 h New Methods of Noise Analysis  
Paper No 5.3 W. Lauterborn, J. Holzfuss, and U. Parlitz,  
Technische Hochschule Darmstadt, Germany

11.00 - 11.30 h Coffee Break

11.30 - 12.10 h On the Scaling of Propeller Cavitation Noise with Account of Scale Effects  
Paper No 5.4 in the Cavitation  
G. Bark, Chalmers University of Technology, Göteborg, Sweden

12.10 - 12.50 h Analysis of Cavitation Noise Measurement of an Onboard Propeller  
Paper No 5.5 B. Bajić and J. Tasić, Brodarski Institut, Zagreb, Croatia

12.50 - 13.45 h Lunch

**Session 6: Cavitation Erosion**

**Chairmen:** K. R. Suhrbier, Vosper Thornycroft (UK) Ltd., Portsmouth, UK.  
C.-A. Johnsson, SSPA Maritime Consulting, Göteborg, Sweden

13.45 - 14.25 h Recent Advances and Future Proposal on Cavitation Erosion Research  
Paper No 6.1 Invited Paper  
H. Kato, University of Tokyo, Japan

14.25 - 15.05 h Evaluation and Prediction of Surface Roughness due to  
Paper No 6.2 Cavitation Erosion  
H. Louis, T. Wehlage, and A. Yabuki, Universität Hannover, Germany

15.05 - 15.30 h Coffee Break

15.30 - 16.10 h Influences of Hydrodynamic Parameters on the Cavitation and Erosion Process  
Paper No 6.3 R. Vollheim, K. Jahn, and K. Bux, Technische Hochschule Dresden, Germany

16.10 - 16.50 h Prevention of Root Erosion by Pre-Propeller Fin  
Paper No 6.4 Y. Ukon and Y. Kurobe, Ship Research Institute, Mitaka, Japan

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**Remark:** The symposium program may be subject to alterations.  
The time schedule for the lectures includes 15 minutes for discussions, except the invited papers.  
It is intended to publish a second bound volume with discussions. Therefore, the discussants are asked to hand in a written discussion version to the STG latest two weeks after the symposium.

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Thursday, June 25nd, 1992

10.00 - 11.30 h Tour through HSVA Facilities

13.00 - 21.00 h Bus Departure for optional  
Sight-Seeing-Tour to Lübeck with e.g.:  
Walk through the historic center,  
Visit of St. Marien-Church, Cathedral, Town-Hall, Dinner in the House of  
the Skippers Guild (Schiffergesellschaft)

## 20<sup>th</sup> ITTC Cavitation Committee Minutes

### Meeting

A meeting of the Cavitation Committee was held on 21 and 22 June 1992 at the Beseler Hof in Hamburg, Germany. These meetings were held in the evening and were in conjunction with the International Symposium on Propulsors and Cavitation organized by the Hamburgische Schiffbau-Versuchsanstalt.

### Membership

Six of the seven active members of the Committee were present: Goran Bark, Michael Billet, Guiseppe Bailo, Gert Kuiper, Jin-Tae Lee, and Yoshi Ukon. Michael Wilson was unable to attend; however, a summary of this meeting was given to Mike during the GTH tests the following week. Jaime Masip has resigned from the Committee and B. Biskoup has not attended any meetings.

### Work of the Committee

The purpose of this meeting was to review the progress made on the recommendations to the 20<sup>th</sup> ITTC Cavitation Committee. A status report was given on the following topics:

1. Effects of Cloud Cavitation - G. Bark
2. Effect of Nuclei Cavitation on Cavitation Inception - M. Billet/G. Kuiper
3. Ship Wake Modelling for Cavitation - J. Lee/Y. Ukon
4. Hull Pressure Fluctuations - Y. Ukon

A general discussion was held about the organization of the report and the schedule. The contributions will be limited to an eight (8) page limit. The final draft from each Committee member will be sent to Gert on a disk (WordPerfect, D-Base). The references will be put on a reference list disk by Gert. The following schedule was tentatively proposed:

**25 August 1992:** Each Committee member will have their written contribution at the Committee meeting in Seoul, Korea for review. Please bring enough copies for each Committee member.

**1 November 1992:** Revised contributions due to Gert. He will distribute these for a second Committee review.

**1 February 1992:** Final draft of each contribution due to Gert. These will then be assembled into the Committee Report by Gert Kuiper and Mike Billet.

**1 March 1992:** Final Committee report completed and sent to the 20<sup>th</sup> ITTC Organization Committee for publication.

The following additional action items were noted:

1. Goran Bark will contact Ed Rood about his contribution to the report.
2. Mike Wilson will contact Guiseppe Bailo about his contribution to the tip vortex work.
3. Mike Wilson will contact Joe Lin about the Committee's response to his letter.
4. Each Committee member will come to the Seoul meeting with a list of recommendations for the 21<sup>st</sup> ITTC Cavitation Committee.
5. Mike Wilson will prepare a brief summary of the LCC to be included in the practical aspects section of the Committee's report.
6. The Committee must decide what additional topics are to be included in the practical aspects section.

#### **Future Meeting**

The next Committee meeting will be held during the 19<sup>th</sup> Symposium on Naval Hydrodynamics to be held during the week of 24-28 August 1992. A tentative schedule is to meet on Monday, 24 August 1992 in Seoul and on Saturday, 29 August 1992 at the Korea Research Institute of Ships and Ocean Engineering. These meetings will be hosted by Jin-Tae Lee, who will distribute a final schedule.